HYBRID VIGOR IN POULTRY

by

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INTRODUCTION

It is a common observation that when two breeds or varieties of plants or animals are crossed, the first generation is frequently more vigorous than either of the two parental forms. This stimulation has been termed hybrid vigor. It may be expressed by increased size, early maturity, greater productiveness, disease resistance, and lower mortality as well as in other ways.

Jones (1917) explained hybrid vigor upon the assumption that dominant favorable factors affecting vigor are responsible for this phenomenon. It has been observed that most mutations are both recessive and detrimental, thus most favorable characteristics must be dominant, and in different breeds or species these factors are different. Crossbreeding brings out the favorable factors and suppresses the unfavorable ones. The hybrid offspring possess a greater number of different factors than either parent and are thus more vigorous. It is also assumed that these vigor factors are linked. This accounts for the fact that there is segregation in the second generation and partly explains why the increased vigor of the first generation is quickly lost in subsequent generations. It would not be possible because of linkage to inbreed the first generation individuals and re-

combine the same sets of vigor factors in subsequent generations producing a strain of individuals showing the same degree of vigor as the first generation. There would accordingly be a decrease in vigor.

This theory is based largely upon results with maize and does not necessarily explain all cases of hybrid vigor. As an exception, we find that many of the detrimental characters in poultry behave as dominants.

Warren (1927) gives the only accurate and complete data available, to the writer's knowledge, on hybrid vigor in poultry. As the criteria for measuring vigor, hatchability, chick mortality, rate of growth, and egg production were used. The first generation hybrids resulting from crossing Single Comb White Leghorns and Jersey Black Giants were found to be superior to the two breeds crossed.

Poultrymen in England are the leaders in hybridization in poultry. The first generation crosses are gaining rapidly in popularity as producers of both meat and eggs. The most recent information available is the final report of the National Egg Laying Test (1928-29) held at Milford, Surrey. The only basis of comparison between the purebred birds and crossbreds exhibited was, of course, the egg production. In the Final Report for the forty-eight weeks, from October 15, 1928 to September 15, 1929, the results of the contest were

given. There were 2592 birds tested in the contest; of this number, 156 were first generation hybrids. The average production of the crosses for the test was 207.54 eggs; the average production for the nearest group of competing purebreds (White Leghorns) was 191.79 eggs. The first generation hybrids thus led the contest by a margin of 15.75 eggs.

This experiment was divided into two phases. The first phase was further divided into two hatches, the entire phase being carried out from October 5, 1929 to January 26, 1930. Phase 2 was carried out during the period, April 13 to July 11, 1930.

The two phases constitute a study of hybrid vigor, but are not comparable in all respects. They were carried out at different seasons of the year and under different conditions of brooding and feeding. Furthermore, none of the crosses made in the first phase were repeated in the second phase.

PURPOSE

Phase I

It was the purpose of this phase of the experiment to compare the vigor of the first generation hybrids with that of the purebred offspring from the breeds used.

The criteria used for comparison were rate of growth to

ten weeks and per cent of mortality to three weeks of age.

Studies were also made on distinguishing sex at hatching and the relation between the weight of chicks at hatching and subsequent weights.

MATERIAL

The individuals used in both phases of the experiment to secure hatching eggs from were part of the experimental flock of the Department of Poultry Husbandry, Kansas State Agricultural College.

METHODS

Breeding Pens

To make the results of phase 1 as comparable as possible, the same groups of individuals were used to produce the purebred and crossbred chicks so far as could be done. In order that one group of purebred chicks and the reciprocal crosses from each of the three breeds might be produced, and also that the nine groups of chicks thus produced might be identified at time of hatching, six groups of females and three groups of males were used.

The males used were as follows: one group of thirteen Single Comb Rhode Island Red males, one group of twelve Single Comb White Leghorns, and one group of thirteen Barred

Plymouth Rocks. The groups of females varied in number, it being necessary to use those that were available without particular attention to the number in each group. Only one group of Rhode Island Red females was used, the males of all three breeds being mated to these. Two groups of Barred Plymouth Rock females were used; to one of these groups only Rhode Island Red males were mated, both White Leghorn and Barred Plymouth Rock males being mated to the other group. Three groups of White Leghorns were used, one group being mated only to White Leghorn males, one being mated only to Rhode Island Red males, and the third group being mated to Barred Plymouth Rock males.

The males were rotated from pen to pen every two days, the change being made at night to cause as little disturbance as possible. By this method of mating, one group of purebred chicks of each breed was produced and also the reciprocal crosses of each of the three breeds; furthermore, many of the chicks were half-brothers and sisters thus reducing to a minimum the influence of the variability of the birds used as parents.

The same individuals and the same system of mating were used in obtaining eggs for both hatches of phase 1, there being just ten days difference between the dates of the two hatches.

Incubation and Pedigreeing

The females were trapnested and the eggs filed daily in a pedigree egg cabinet. The date of laying and also the leg band number of the female were recorded on each egg. Individual egg records were kept of each female, as the chicks were pedigree hatched.

It was planned to have fifty chicks from each mating in each hatch. Because of the low production, fertility, and hatchability at the season of the year in which this part of the experiment was undertaken, a larger number of eggs had to be saved than was usually necessary to be reasonably assured of obtaining the number of chicks desired. In addition to these reasons, there was also a limited number of producing females in each of the mating pens and a sufficient number of eggs could not be had in ten days, hence the necessity of the two hatches.

The eggs for hatches 1 and 2 were set in a forced draft incubator which was located in Waters Hall. The eggs were turned three times daily, and candled on the ninth and eighteenth days of incubation.

Records were kept of all infertile eggs and of all dead embryos on the ninth and eighteenth days.

On the eighteenth day of incubation the eggs of each

female were placed in individual pedigree sacks in order to have individual hatching records of each female and also that the pedigree record of each chick might be had.

The chicks were removed from the incubator on the twenty-second day after the date of setting. They were wing-banded, individually pedigreed, and individually weighed at this time. The weight of each chick was recorded to the nearest gram.

Brooding

On the day following the removal from the incubator, the chicks were taken to a brooder house at the College Poultry Farm. Water and feed were placed before the chicks when they were put in the brooder house and left before them thereafter. The Kansas all-mash chick ration as found in C. Form 1, 1930, was fed.

Hatches 1 and 2 were placed in adjoining rooms in the brooder house, all chicks of a hatch being brooded together on the floor under the same brooder. A gas heated brooder was used in each room, and every effort was put forth to make environmental conditions as nearly the same as possible for the two hatches.

EXPERIMENTAL RESULTS

Rate of Hatching

While hatch 2 was in progress, an attempt was made to observe the comparative rates of hatching of the purebred and crossbred chicks.

Observations were made on the eggs from the two groups of females that produced both purebred and hybrid offspring. These were the Rhode Island Reds and one group of Barred Plymouth Rocks. The Rock females had been mated to purebred Rock males and also to White Leghorns, and the Red females had been mated to males of all three breeds used. These conditions afforded a comparison of the rates of hatching. No observations were made on the chicks from the Leghorn females.

During the course of the hatching, two counts were made of the hybrid and purebred chicks from these females, the chicks being identified by color. On the day that the eggs were set, they were placed in the incubator between 11:00 and 12:00 o'clock in the morning. The chicks began hatching on the morning of the twentieth day of incubation. Two counts were made on this day, the first being at 4:00 p. m. and the second at 10:00 p. m.

From the observations made, the hybrid chicks were found to hatch earlier than the purebreds. At the time of the first observation, many of the crossbreds were fluffed out while a larger number of the purebreds were not.

Table I. Rate of hatching

Mating	Total number chicks	Number hatched at first observation	Per cent hatched
Purebred Rocks	52	3	5.77
Leghorn male X Rock female	20	11	55.00
Purebred Reds	63	18	28.57
Leghorn male X Red female	29	17	58.62
Rock male X Red female	92	34	36.96

Table I shows the total number of chicks from the five matings and also the number of purebreds and crossbreds hatched when the first observation was made. At the first count, 5.77% of the purebred Rocks were hatched, while 55.00% of the hybrids from these females had hatched. There were 28.57% of the purebred Reds hatched, while 58.62% of the hybrids from the Leghorn male by Red female mating, and 36.96% of the hybrids from the Rock male by Red female mating were hatched.

Distinguishing Sex at Hatching

It has been known for many years that sex-linked characters are present in poultry. The factor for barring is one of the best known. Serebrovsky (1922) showed that the rate of feathering was a sex-linked character. In planning this experiment, these two sex-linked factors were involved and an attempt was made to segregate the sexes at hatching as far as the matings rendered it possible.

In the fowl, the female is the heterogametic sex, the male being homogametic. The "criss-cross" type of inheritance results from crosses if the recessive sex-linked factors are brought into the cross through the male. The first generation females will bear the characters of the sire and the first generation males those of the dam. On the basis of this difference, the sexes may be distinguished at hatching.

The rate-of-feathering factor is a juvenile characteristic and refers to the age at which the down is replaced by the adult type of feathers. Early-feathering is recessive to late-feathering. The barring characteristic is well known and need not be defined. It is a dominant factor, however, its normal recessive allelomorph being black or the non-barred condition.

Immediately after the chicks were banded and weighed, they were separated according to sex. Before attempting this, however, several chicks in each group were examined and measurements made of the primary feathers of the wing. Those chicks bearing head spots were also examined as to the varying size of the head spot. These steps were taken in order to set up a basis for comparison in the separation of the sexes.

Barring and Non-barring Factors. Some poultrymen hold the opinion that there is a difference in the size of the white or buff head spot in the sexes in purebred Barred Plymouth Rock chicks. The males tend to have a larger spot than the females and in general the down is lighter in color. In hatches 1 and 2 an attempt was made to segregate the purebred Barred Plymouth Rock chicks as to sex upon the basis of the comparative size of the white head spot. Considerable difficulty was encountered as to where the division line should be drawn as to size of head spots in the classification.

There were 118 chicks in the two hatches from this mating examined in the attempt to segregate the sexes on the basis of the size of the head spot. The sexes were segregated with 66.1% accuracy. The prediction for the females was 65.6% correct and 66.7% for the males.

In the Rhode Island Red male by Barred Plymouth Rock female mating barring and non-barring factors are involved. Since the males used in this cross are non-barred and the females barred, and since barring is dominant to non-barring, the male offspring should be barred (show head spot) and the females non-barred or black (no head spot). On this basis of down color, the chicks from this cross were separated as to sex in both hatches. The sexes of the 107 chicks from this cross were predicted with absolute accuracy in both hatches. It was not at all difficult to segregate the sexes of these chicks by using the down color as the basis for classification. The males were black and possessed a distinct white or buff head spot, while the females were distinctly black in down color having no head spot.

Early- and Late-feathering Factors. The chicks from the White Leghorn male by Rhode Island Red female mating were segregated according to sex on the basis of the rate-of-feathering factor. The White Leghorn carries the factor for early-feathering. Since this is recessive to the factor for late-feathering, which is carried by the Rhode Island Reds, the female offspring from this cross should have long flight feathers at hatching and the males should have short flights.

In hatch 1, only group comparisons were made with this

group. In hatch 2, the sexes were separated by observing the length of the primary instead of taking measurements, the early-feathering chicks being classed as females and the late-feathering chicks classed as males.

The chicks from this mating in the second hatch only were classified as to sex. This classification was made on the basis of the rate of feathering. The sexes for the group of twenty-eight chicks were predicted with 89.3% accuracy. The predictions for the females alone proved to be 92.9% correct, and those for the males 85.7% correct.

The chicks from the Leghorn male by Rock female mating should show differences in the length of the primary feathers as did the chicks from the previous mating. The male offspring should be late-feathering, since the Rock females carry the factor for late-feathering. The female offspring should be early-feathering, since this factor is recessive and was brought into the cross through the male.

The lengths of the primaries were taken of the chicks in the first hatch, the lengths varying from four to twelve millimeters. Those chicks whose feathers were nine millimeters or below were classed as males, those measuring ten millimeters and above being classed as females.

In hatch 2, the segregation was made first, then the measurements taken of the feathers afterwards. The segrega-

tion proved to be 82.4% correct for the two hatches consisting of seventy-four chicks. When the females were considered alone, the accuracy was 71.4%. The degree of accuracy for the males alone was 92.3%.

Chick Mortality

Daily records were kept of the mortality in both hatches from the date of the first weight till the chicks were ten weeks of age. The mortality till three weeks was charged against vigor, the mortality afterwards being generally conceded to be due to factors other than low vigor.

No accidental deaths were included in the mortality record. Accidental deaths included those due to drowning, to injuries received, and to development of enlarged hocks and wry-necks.

Each chick that died was examined to obtain the sex for use in the weight records.

Table II. Chick mortality

Mating	Hatch 1			Hatch 2			Total		
		Mortality			Mortality			Mortality	
	Number chicks	Number	Per cent	Number chicks	Number	Per cent	Number chicks	Number	Per cent
Purebred Leghorns	50	5	10.0	51	5	9.8	101	10	9.9 ± 2.00
Purebred Reds	39	5	12.8	48	7	14.6	87	12	13.8 ± 2.50
Purebred Rocks	66	12	18.2	51	10	19.6	117	22	18.8 ± 2.43
Leg. male X Red female	47	1	2.1	28	2	7.1	75	3	4.0 ± 1.52
Leg. male X Rock female	52	4	7.7	18	0	0.0	70	4	5.7 ± 1.87
Red male X Leg. female	15	1	6.7	17	1	5.9	32	2	6.3 ± 2.90
Red male X Rock female	57	1	1.8	50	4	8.0	107	5	4.7 ± 1.38
Rock male X Leg. female	65	5	7.7	48	0	0.0	113	5	4.4 ± 1.30
Rock male X Red female	55	2	3.6	48	3	6.3	103	5	4.9 ± 1.44

It is to be seen from Table II that the mortality of the purebred chicks was much higher than that of the hybrids. In every group of the hybrids the per cent mortality was lower than in any group of the purebreds.

In two groups of hybrids in the second hatch, it is to be noted that there was no mortality. When both hatches are considered together, it is found that the per cent mortality of the hybrids ranges from 4.0 to 6.3 per cent while that of the purebreds ranges from 9.9 to 18.8 per cent.

Table III shows the ratio of the difference in mortality to the probable error of the difference between the purebreds and crossbreds. The differences in total per cent mortality between the purebred Leghorns and the purebred Reds and the hybrids originating from each of these two breeds were not significant. The difference between the purebred Rocks and the hybrids originating from this breed was considered significant in every case. The per cent difference between the Rocks and the Leghorn-Rocks was 13.1 ± 3.09; that between the Rocks and the Rock-Leghorns was 14.4 ± 2.77; that between the Rocks and the Red-Rocks was 12.1 ± 2.81; and that between the Rocks and the Rock-Reds was 13.9 ± 2.84.

Table III. Ratio of difference in mortality to the probable error of the difference between the purebreds and crossbreds.

	Leg. male X Red female	Red male X Leg. female	Leg. male X Rock female	Rock male X Leg. female	Red male X Rock female	Rock male X Red female
Purebred Leghorns	2.35	1.02	1.53	2.30		
Purebred Reds	3.34	1.96			3.19	3.09
Purebred Rocks			4.27	5.22	5.05	4.93

Rate of Growth

The first weight of the chicks, as was previously mentioned, was taken at the time of hatching. The second weight was taken eight days afterwards. Weights were then recorded weekly until the chicks were four weeks of age. The weighing was then done at bi-weekly intervals until the chicks were ten weeks old, when this phase of the experiment was terminated. The chicks were weighed individually to the nearest gram to four weeks of age, and thereafter to the nearest five grams. All feed and water were removed from the chicks on the night preceding each weighing, the weights being taken early in the morning. On the date of the last weighing, color descriptions of each chick were made and the sex of each chick recorded so that the weight records could be calculated according to sex.

In computing all weights, the male and female weights were treated separately in order to obtain the average weight of each sex. In figures 1, 2, 3, and 4, the average of the average weights of the males and the females in hatches 1 and 2 have been used.

The rate of growth to ten weeks of the White Leghorns, Rhode Island Reds, and the reciprocal crosses are shown in figure 1. It is seen that the hybrids are consistently

heavier than either of the groups of purebreds from which they originated. At the age of two weeks some difference is first noted in the weights. At ten weeks, the differences between the weights of the hybrids and purebreds is very marked, the purebreds ranging between 600 and 700 grams and the hybrids ranging between 700 and 800 grams.

Figure 2 shows the comparison of weights of the Rhode Island Reds, Barred Plymouth Rocks, and the reciprocal crosses. These data show that both groups of hybrids are consistently heavier throughout the period of ten weeks than either group of purebreds. At two weeks, there is some difference to be seen between the hybrids and purebreds, and at ten weeks the differences have become very noticeable. The average of the heaviest group of the purebreds does not reach 700 grams, while the best group of hybrids averaged approximately 800 grams.

The data presented in figure 3 illustrate the differences in weight of the White Leghorns, Barred Plymouth Rocks and the reciprocal crosses. There is not the clean cut difference between the hybrids and the purebreds in figure 3 as was found in figures 1 and 2. The hybrids from the Rock male by Leghorn female mating are, however, consistently heavier throughout the period than are either group of purebreds. The chicks from the Leghorn male by Rock female mating had a growth curve very similar to the pure Leghorns.

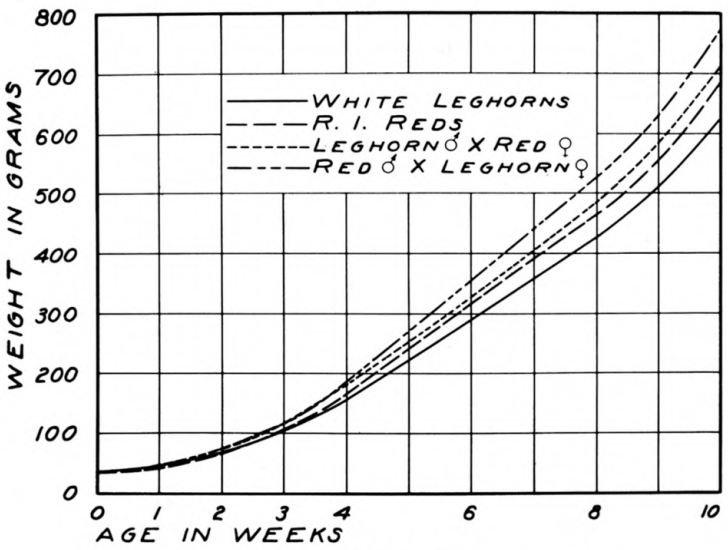

Figure 1

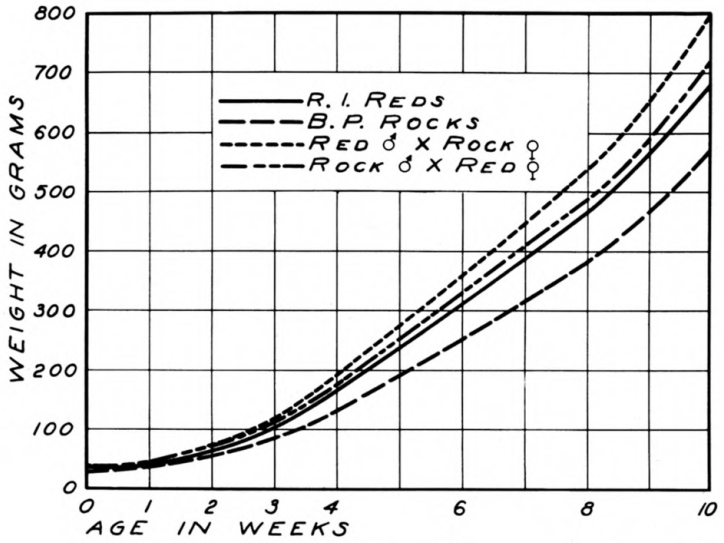

Figure 2

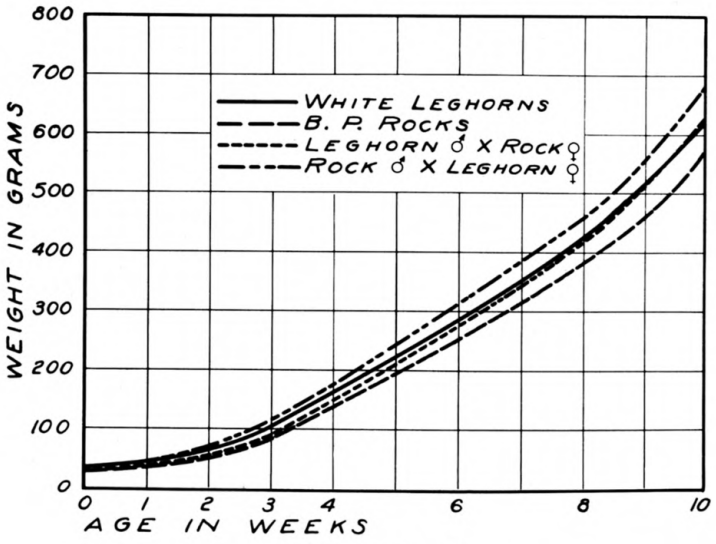

Figure 3
Comparison of growth of pure-breds and hybrids

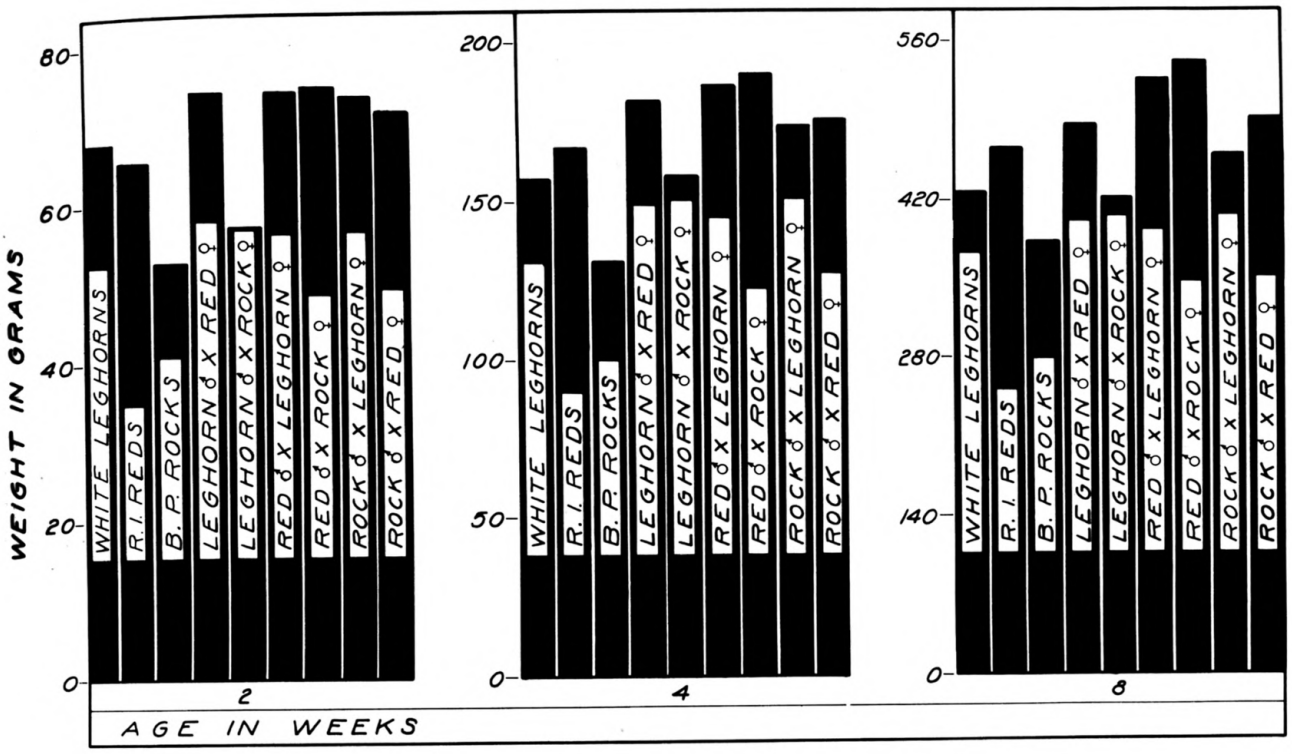

Figure 4. Comparison of hybrids and purebreds at two, four, and eight weeks, giving average of male and female averages.

In all the data presented it is to be noted that in weight the purebred Barred Plymouth Rocks and the chicks from the Leghorn male by Rock female mating are in general the two poorest groups in the experiment. The females producing these two groups of chicks were purebred Barred Plymouth Rock pullets, the only group of pullets used in the experiment. Their egg size was far below the average of the other females used in the matings. The chicks from these individuals were the lowest in weight at hatching, and never seemed to overcome the handicap.

The more reliable method of comparing the weights of the four groups of chicks in figure 3 would be to compare the hybrids from the Rock male by Leghorn female mating with the pure Leghorns, and the hybrids from the Leghorn male by Rock female mating with the pure Rocks. The comparison would then be made between two groups of chicks coming from females laying approximately the same size of egg. The size of egg would not then affect the comparisons made.

Figure 4 graphically presents a comparison of the weight of the chicks from all the matings at two, four, and eight weeks of age. This affords a comparison of the hybrids and purebreds. The hybrids as a group average heavier than the purebreds. The purebred Reds were heavier at four and at eight weeks than the other purebreds, although the

Leghorns were heavier the second week. The Rocks weighed the least of the purebreds at all ages.

Of the hybrids, the chicks from the Red male by Rock female mating were the heaviest at two, four, and eight weeks. The hybrids from the Leghorn male by Red female mating ranked second at two weeks, but the hybrids from the Red male by Leghorn female mating ranked second at four and at eight weeks. The offspring from the Leghorn male by Rock female mating were the poorest of the hybrids at all ages.

In Tables IV and V are presented the average weights to ten weeks of age of all the groups of chicks in hatches 1 and 2.

It will be observed that the weights in Table V are slightly lower in most cases than in Table IV. It is thought that the chicks in the second hatch were slightly chilled between the time they were removed from the incubator and the time they were placed in the brooder room. An outbreak of diarrhea was noticed during the first two weeks of brooding, and this seemed to affect the growth thereafter. The only cause that can be attributed to the diarrhea was the apparent chilling as all eggs were from blood tested stock.

Table IV. Growth (in grams) of purebreds and hybrids in hatch 1.

Mating		Age							
		1 day	1 wk.	2 wks.	3 wks.	4 wks.	6 wks.	8 wks.	10 wks.
White Leghorns	Male	36.2	47.0	76.7	118.8	178.7	339.6	467.0	691.5
	Female	35.1	43.0	67.5	102.4	151.8	286.0	394.7	579.2
	Average	35.7	45.0	72.1	110.6	165.3	312.8	430.9	635.4
Rhode Island Reds	Male	37.8	43.9	70.9	113.7	179.9	356.1	494.7	735.3
	Female	38.1	43.6	69.7	112.1	173.6	324.1	427.1	637.4
	Average	38.0	43.8	70.3	112.6	176.8	340.1	460.9	686.4
Barred Plymouth Rocks	Male	29.8	34.5	55.3	89.8	141.5	286.5	393.0	591.5
	Female	29.3	34.5	56.2	88.0	134.0	261.9	364.0	565.0
	Average	29.6	34.5	55.8	88.9	137.8	274.2	378.5	578.3
Leg. male X Red female	Male	37.9	49.0	82.1	130.0	195.0	372.3	522.5	784.4
	Female	36.6	44.8	72.8	113.0	171.1	312.0	424.1	630.2
	Average	37.3	46.9	77.5	121.5	183.1	342.2	473.3	707.3
Leg. male X Rock female	Male	29.1	37.8	63.2	102.4	159.9	318.2	454.4	697.2
	Female	29.0	37.0	62.0	98.3	151.5	290.5	410.0	615.5
	Average	29.1	37.4	62.6	100.4	155.7	304.4	432.2	656.4
Red male X Leg. female	Male	36.0	50.2	84.2	133.2	213.3	436.7	600.0	919.2
	Female	34.9	44.6	74.4	121.0	178.8	355.6	497.5	715.0
	Average	35.5	47.4	79.3	127.1	196.1	396.2	548.8	817.1
Red male X Rock female	Male	38.1	50.2	82.0	129.1	205.8	418.5	579.4	886.3
	Female	37.8	47.0	77.8	121.9	194.0	377.0	529.2	784.8
	Average	38.0	48.6	79.9	125.5	199.9	397.8	554.3	835.6
Rock male X Leg. female	Male	36.9	47.2	77.9	123.9	187.7	367.7	506.2	775.5
	Female	36.7	44.2	70.8	108.2	160.5	298.2	411.5	604.0
	Average	36.8	45.7	74.4	116.1	174.1	333.0	458.9	689.8
Rock male X Red female	Male	38.2	48.1	79.9	126.1	197.5	389.8	537.7	818.0
	Female	36.8	43.8	72.9	112.5	174.8	339.8	465.7	706.1
	Average	37.5	46.0	76.4	119.3	186.2	364.8	501.7	762.1

Table V. Growth (in grams) of purebreds and hybrids in hatch 2.

Mating		Age							
		1 day	1 wk.	2 wks.	3 wks.	4 wks.	6 wks.	8 wks.	10 wks.
White Leghorns	Male	35.4	46.2	67.8	104.3	162.9	285.3	460.2	674.1
	Female	34.2	40.4	59.6	90.3	132.7	242.1	382.1	554.7
	Average	34.8	43.3	63.7	97.3	147.8	263.7	421.2	614.4
Rhode Island Reds	Male	33.6	39.6	59.9	95.7	158.2	305.3	494.8	727.0
	Female	34.3	39.7	61.1	96.3	154.3	281.8	443.8	645.3
	Average	34.0	39.7	60.5	96.0	156.3	293.6	469.3	686.2
Barred Plymouth Rocks	Male	28.2	35.5	51.6	81.4	127.3	243.3	407.2	589.1
	Female	28.0	33.5	48.9	76.8	120.5	229.5	367.3	548.8
	Average	28.1	34.5	50.3	79.1	123.9	236.4	387.3	569.0
Leg. male X Red female	Male	34.1	43.6	67.8	109.2	181.9	319.6	517.3	756.9
	Female	35.1	46.8	73.5	114.5	176.5	303.1	479.6	677.3
	Average	34.6	45.2	70.7	111.9	179.2	311.4	498.5	717.1
Leg. male X Rock female	Male	28.3	35.7	51.1	81.4	126.7	252.9	421.4	642.1
	Female	26.7	34.8	53.0	84.9	135.2	245.9	394.5	574.5
	Average	27.5	35.3	52.1	83.2	131.0	249.4	408.0	603.3
Red male X Leg. female	Male	35.2	45.2	67.0	103.8	171.8	311.0	500.0	753.0
	Female	33.3	44.1	70.4	112.4	180.0	324.1	506.8	707.7
	Average	34.3	44.7	68.7	108.1	175.9	317.6	503.4	730.4
Red male X Rock female	Male	37.5	45.8	71.8	111.7	183.8	341.9	552.5	812.3
	Female	34.0	43.6	67.0	105.1	171.4	306.3	494.8	714.5
	Average	35.8	44.7	69.4	108.4	177.6	324.1	523.7	763.4
Rock male X Leg. female	Male	34.9	45.5	70.9	111.6	175.7	302.5	489.3	730.0
	Female	36.9	47.4	73.1	110.6	166.8	282.0	426.8	628.0
	Average	35.9	46.5	72.0	111.1	171.3	292.3	458.1	679.0
Rock male X Red female	Male	34.5	43.1	66.4	102.7	165.6	301.5	489.5	697.4
	Female	34.4	44.0	67.0	102.3	161.1	295.2	464.8	685.8
	Average	34.5	43.6	66.7	102.5	163.4	298.4	477.2	691.6

From a study of Tables IV and V it is seen that if the weights at hatching are excluded, and if an exception is made of the chicks from the Leghorn male by Rock female mating, the hybrids are found to average heavier in every case than either of the two groups of purebreds from which they originated.

Effect of Weight at Hatching on Subsequent Weights

Halbersleben and Mussehl (1922) found that the heavier chicks at hatching were produced from the heavier eggs, and that at thirty-five days of age, any apparent advantage possessed by the chicks from the larger eggs had nearly disappeared. Jull and Quinn (1925) also found that the weight of the egg influenced the weight of the chick at hatching. Upp (1928) likewise found a high degree of association between egg weight and day-old chick weight, but that the day-old weight was an unreliable index of the chicks' weight when two, four, or twelve weeks of age.

In studying the relation between the chick weight at hatching and subsequent weights in this experiment, a comparison was made at two, four, and eight weeks. The two hatches were treated separately, as were the sexes, also. The weights of twenty chicks of each sex where possible (in smaller groups than twenty all the weights were used) were

taken from each group in each hatch, excepting the purebred Rocks, the chicks from the Leghorn male by Rock female mating, and the chicks from the Red male by Leghorn female mating. In selecting these weights for study, in order to obtain as representative a group as possible, they were taken in consecutive order from the records. As will be seen in Tables VI, VII, and VIII, the weight of the chicks at hatching was divided into two classes, those weighing thirty-six grams and above and those weighing below thirty-six grams. It was thought that this weight was representative of the average size chick. Those weighing below thirty-six grams were classed as small, and those weighing thirty-six grams and above were classed as large. The chicks from the Red male by Leghorn female mating were not included in this study because of the small number. The purebred Rock chicks and those from the Leghorn male by Rock female mating were not considered on account of their exceptionally small size. It was thought that the results would have been unduly biased for these reasons.

Table VI. Effect of weight at hatching on the weight at two weeks.

	Grams	41-50	51-60	61-70	71-80	81-90	91-100	Mean Weights
Males								
Hatch 1	Below 36	1	3	11	10	10	0	72.14 ± 1.21
	36 and above	0	3	10	27	32	11	79.58 ± .73
Hatch 2	Below 36	2	15	41	10	0	0	63.68 ± .56
	36 and above	1	5	11	19	8	1	71.89 ± 1.03
Females								
Hatch 1	Below 36	0	6	19	10	4	0	68.08 ± .92
	36 and above	1	7	19	29	21	1	73.33 ± .77
Hatch 2	Below 36	9	13	31	11	2	0	62.58 ± .82
	36 and above	2	6	8	18	10	0	71.36 ± 1.13

Table VII. Effect of weight at hatching on the weight at four weeks.

	Grams	101-125	126-150	151-175	176-200	201-225	226-250	251-275	Mean Weights
Males									
Hatch 1	Below 36	0	6	10	11	6	1	1	179.64 ± 3.39
	36 and above	0	4	16	31	26	5	1	192.02 ± 1.87
Hatch 2	Below 36	2	13	41	9	2	0	0	161.01 ± 1.55
	36 and above	4	1	12	15	13	1	0	181.52 ± 2.99
Females									
Hatch 1	Below 36	1	13	15	10	2	0	0	161.89 ± 2.43
	36 and above	4	9	31	21	12	0	0	171.59 ± 2.02
Hatch 2	Below 36	14	15	28	10	1	0	0	151.10 ± 2.09
	36 and above	4	8	11	13	6	0	0	167.86 ± 3.09

Table VIII. Effect of weight at hatching on the weight at eight weeks.

	Grams	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	Mean Weights
Males										
Hatch 1	Below 36	0	1	10	10	6	4	2	1	492.65 ± 8.05
	36 and above	0	2	12	17	23	21	6	2	520.18 ± 4.90
Hatch 2	Below 36	2	4	13	22	19	7	0	0	479.48 ± 4.87
	36 and above	3	3	4	7	5	14	9	0	520.55 ± 9.10
Females										
Hatch 1	Below 36	3	13	11	7	4	2	0	0	427.50 ± 6.85
	36 and above	5	19	22	12	16	2	0	0	438.82 ± 5.01
Hatch 2	Below 36	5	10	24	19	8	1	1	0	441.18 ± 4.93
	36 and above	4	5	11	13	6	1	2	0	452.38 ± 7.46

At two weeks of age, the mean difference between the weights of the males in hatch 1 that were classed as large and small at hatching was 7.44 ± 1.41, which is significant. For the females, this difference was 5.25 ± 1.20. This is considered significant. The mean difference between the weights of the males in hatch 2 at this same age was 8.21 ± 1.17, which is a significant difference. That for the females was 8.78 ± 1.40, which also proves to be significant.

At four weeks, the mean difference between the males in hatch 1 that were classed as large and as small at hatching was 12.38 ± 3.87. This is of no significance. The difference between the mean weights of the females was 9.70 ± 3.16, which is of no significance. The difference between the males in hatch 2 was 20.51 ± 3.37, which is significant; that for the females was 16.76 ± 3.73, and is also significant.

The mean difference at eight weeks between the males in hatch 1 was 27.55 ± 9.42, which is not significant. The difference between the females in this same hatch was 11.32 ± 8.49, which is not significant. The difference between the males in hatch 2 at this age was found to be 41.07 ± 10.33, This would be considered a significant difference by some, while others would not consider it significant. The difference between the females in hatch 2 was 11.20 ± 8.91, which is of no significance.

DISCUSSION

There was a total of 869 chicks at the beginning of this experiment. At the time the per cent mortality was figured (Table II) this number, it is seen, was reduced to 805. There were several accidental deaths, and several of the wing bands were lost during the first week, thus accounting for this.

It is shown in Table II that the number of chicks from the Red male by Leghorn female mating is unusually small. There was a very high per cent of infertile eggs from the females in this mating, and it is believed that interference in mating caused this. The small number of chicks in the other groups was due to low egg production.

The differences found between the purebreds and hybrids in the rate of hatching were apparently due to hybrid vigor.

A comparison of the mortality of the hybrids and purebreds is distinctly in favor of the hybrids. Should these differences be found in a commercial enterprise where large number of chicks are raised yearly, the superiority of the hybrid could be clearly seen in this one respect.

From the study made of the rate of growth of the hybrids and purebreds, it is seen that the hybrids have a decided advantage. Most of the comparisons were made at ages up to eight weeks. It is probably true that the weights at six

or eight weeks are most representative of hybrid vigor, and that at above eight weeks the weight-at-maturity factor begins to influence the growth.

There seems to be some evidence from these studies that the vigor of the purebreds is reflected in their hybrids at least regarding growth. The slowest growing hybrids are from the two slowest growing purebreds. The most rapid growing hybrids are those in which is involved the most rapid growing purebreds. There are exceptions, of course, but the evidence seems to support the view that the hybrids reflect the vigor of the purebreds involved in their origin.

These differences are illustrated best in figure 4. At four and eight weeks, the hybrids from the Leghorns and Rocks are seen to be the slowest growing hybrids in the group. The purebred Leghorns and purebred Rocks are also the slowest growing purebreds. It is seen that the hybrids from the Reds and Leghorns are among the best. Both these purebreds grew faster than did the purebred Rocks. The purebred Reds were the most rapid growing groups of purebreds, and their hybrids were among the best at four and at eight weeks.

As an exception to this, it is seen that the chicks from the Red male by Rock female were the heaviest hybrids at four and eight weeks. In this exception, the fact must be considered that these Rock females were not used in any

of the other matings. These were mature females that laid eggs much larger than those from the Rock pullets. The chicks from these two groups of Rock females are, therefore, not as comparable as they might have been had they come from the same female parentage. The very rapid growing nature of the purebred Reds was apparently reflected in the growth of these hybrids and seemed to offset the slow growing nature of the purebred Rocks.

The error was very high in distinguishing the sex in purebred Barred Plymouth Rocks by the size of the head spot. It is believed that the error might have been reduced to some extent by observing the shank color at the same time the head spot was examined. The females are said to have darker shanks than the males.

Where the barring and non-barring factors are involved, the results show that the sex of the chicks can be distinguished 100 per cent correctly.

The results from distinguishing sex on the basis of the early- and late-feathering factors were accurate to a fairly high degree. It is very probable that some of the females used in these matings were not pure for late-feathering. This likely accounts for part of the error involved. It is thought that if the chicks had been segregated at about the time most of them had fluffed out, the error would have been further reduced. The proper time to separate the

sexes using this factor seems to be when the majority of the hatch is well fluffed out. If the time is delayed much later, there is apt to be some difficulty in distinguishing between the earlier feathering males and the later feathering females.

PURPOSE

Phase II

The purpose of this phase of the experiment was to make further studies of hybrid vigor on various crosses. The criteria used for comparison were rate of growth to eight weeks and per cent of mortality to three weeks of age. Studies were also made on the consumption of feed in relation to the gain in weight.

METHODS

The procedure followed in this part of the experiment was the same as that used in the first phase so far as the mortality records and weight records are concerned. Where the procedures differ will be pointed out in the following paragraphs.

Breeding Pens

There were seven groups of females used in the matings. Four of these groups were Single Comb White Leghorns, two were Rhode Island Reds, and one was Dark Cornish. Black Giant males were mated to one group of the Leghorn females; Black Minorca males were mated to another group; White Leghorn males were mated to the third group; Dark Cornish males were mated to the remaining group of the Leghorn females. Rhode Island Red males were mated to one group of the Red females, and Dark Cornish males were mated to the other group. Only Dark Cornish males were mated to the Cornish females.

Seven groups of chicks were produced from these matings, there being five groups of hybrids and two of purebreds. There were three groups of chicks from the matings in which the Cornish males were used. These were the only groups that were closely related, for the same Cornish males were used in these matings with the Leghorn, Red, and Cornish females.

Incubation

The eggs were saved for a period of ten days, and were incubated in a mammoth type incubator located at the College Poultry Farm. No individual pedigree records were kept of

the chicks as was done in phase 1. The chicks were removed from the incubator on the twenty-first day after the date of setting. They were wing-banded and individually weighed at this time.

Brooding

On the same day that the chicks were removed from the incubator, they were placed in a battery brooder. The following all-mash ration was fed:

Yellow corn meal	44 lbs.
Wheat bran	15 "
Ground oat groats	15 "
Meat cracklings	10 "
Dried buttermilk	5 "
Alfalfa leaf meal	5 "
Salt	1 "
Cod liver oil	1 "
Steamed bone meal	2 "
Calcium carbonate	2 "

The room in which the chicks were brooded was equipped with a gas heated brooder stove and a system of forced ventilation. All the chicks from a mating were brooded together in the same tray of the battery brooder, except those from the Cornish male by Red female mating and the purebred Cornish. Because of the small number of chicks from these two matings, the two groups were brooded in the same tray.

The position of the trays in the brooder was changed at frequent intervals in order to minimize the effect of any difference in temperature that might have existed at differ-

ent elevations.

The chicks were kept in the battery brooder until they were five weeks old, when they had to be taken out because of a severe outbreak of cannibalism. They were removed to a pen with a hardware cloth sanitary runway, all seven groups of chicks being turned together. They remained here until the experiment ended.

EXPERIMENTAL RESULTS

Chick Mortality

Table IX shows the number of chicks from each mating, the number of deaths and the per cent mortality. The small number of chicks from the purebred Cornish and the Cornish-Red matings was due to the limited number of females that were available for use in the breeding pens.

The per cent mortality of the hybrids ranged from 2.7 per cent in the Giant-Leghorns to 21.1 per cent in the Cornish-Reds. The range for the purebreds was from 2.7 per cent in the Leghorns to 29.2 per cent in the Cornish.

There was no significant difference in mortality between the purebred Leghorns and the purebred Reds. The difference was 9.6 ± 2.88, which is only 3.33 times the probable error. A difference considered significant was found between the purebred Leghorns and the purebred Cornish. The

difference was 26.5 ± 6.39, and is 4.15 times the probable error. The difference between the purebred Reds and the purebred Cornish was 16.9 ± 6.77, only 2.50 times the probable error, and is not significant.

No significant difference was found between the mortality of the purebred Cornish and the Cornish-Leghorns. The difference was 21.8 ± 6.70, only 3.25 times the probable error. The difference between the Cornish and the Cornish-Reds was not significant, being 8.1 ± 8.89, only .91 times the probable error. The difference in mortality between the Reds and the Cornish-Reds was 8.8 ± 6.82, which is not significant, being only 1.29 times the probable error. The differences in mortality between the Leghorns and the Leghorn hybrids were not significant. There was no difference between the Leghorns and the Giant-Leghorns. That between the Leghorns and the Minorca-Leghorns was 1.4 ± 2.00, only .7 times the probable error. That between the Leghorns and the Cornish-Leghorns was 4.7 ± 2.71, only 1.73 times the probable error.

Table IX. Chick mortality

	Number chicks	Mortality	
		Number	Per cent
Giant X Leghorn	74	2	2.7 ± 1.27
Minorca X Leghorn	74	3	4.1 ± 1.55
White Leghorns	74	2	2.7 ± 1.27
Rhode Island Reds	73	9	12.3 ± 2.59
Cornish X Leghorn	54	4	7.4 ± 2.40
Cornish X Red	19	4	21.1 ± 6.31
Dark Cornish	24	7	29.2 ± 6.26

Rate of Growth

In Table X are presented the average weights of the chicks from the seven matings until eight weeks of age. From a study of this table it is seen that the hybrids as a group were not consistently heavier than the purebreds as in the first phase. In most cases, however, the hybrids were heavier.

A comparison of the growth of the seven groups of chicks at two, four, and eight weeks is presented graphically in figure 5. The Minorca-Leghorn hybrids were the heaviest at

all ages. The Giant-Leghorn hybrids ranked intermediate. The Cornish-Red hybrids were the poorest group of hybrids at all ages. The purebred Leghorns were the second heaviest group at two and four weeks, but the Cornish-Leghorn hybrids were second at eight weeks. The purebred Leghorns were the heaviest purebreds at all ages, the Reds ranking second and the Cornish ranking third.

Table X. Growth (in grams) of chicks in phase 2

Mating		Age						
		1 day	1 wk.	2 wks.	3 wks.	4 wks.	6 wks.	8 wks.
Black Giant male	Male	36.4	51.1	77.7	113.7	175.3	342.1	461.5
X	Female	37.3	50.9	76.4	111.5	166.0	309.7	410.6
White Leghorn female	Average	36.9	51.0	77.1	112.6	170.7	325.9	436.1
Black Minorca male	Male	37.5	55.0	79.6	128.7	196.2	377.6	529.6
X	Female	38.6	56.0	82.7	129.9	189.8	340.6	464.9
White Leghorn female	Average	38.1	55.5	81.2	129.3	193.0	359.1	497.3
	Male	37.5	56.8	81.4	128.0	189.6	341.8	465.9
Purebred White Leghorns	Female	36.7	56.6	80.2	123.4	179.5	315.8	422.1
	Average	37.1	56.7	80.8	125.7	184.6	328.8	444.0
	Male	38.6	50.0	73.6	116.6	184.5	357.1	452.1
Purebred Rhode Island Reds	Female	37.4	50.5	72.4	112.0	170.4	309.2	388.3
	Average	38.0	50.3	73.0	114.3	177.5	333.2	420.2
Dark Cornish male	Male	35.9	48.9	73.2	117.2	183.4	342.3	489.1
X	Female	35.5	48.4	70.3	108.5	169.3	311.2	432.2
White Leghorn female	Average	35.7	48.7	71.8	112.9	176.4	326.8	460.7
	Male	34.8	42.1	57.5	83.3	134.6	273.8	386.3
Purebred Dark Cornish	Female	34.6	46.4	62.1	93.4	148.1	286.9	415.7
	Average	34.7	44.3	59.8	88.4	141.4	280.4	401.0
Dark Cornish male	Male	35.4	43.8	66.6	98.8	155.4	323.0	398.0
X	Female	36.6	43.8	65.9	101.7	167.0	322.0	439.0
Rhode Island Red female	Average	36.0	43.8	66.3	100.3	161.2	322.5	418.5

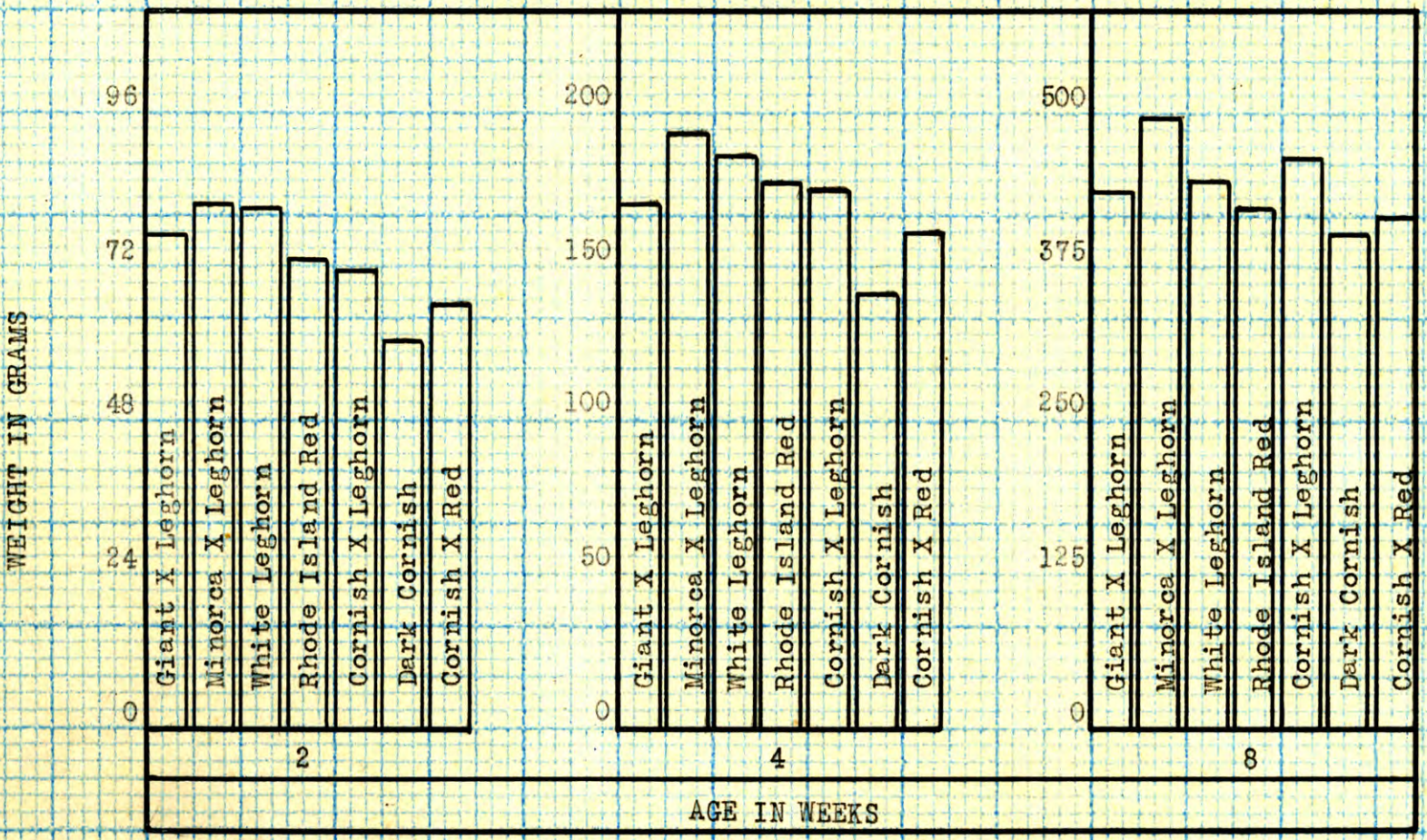

Figure 5. Comparison of growth of chicks at two, four, and eight weeks

Feed Consumption in Relation to Gain in Weight

An attempt was made in this phase of the experiment to find whether or not the hybrids gained more weight per unit of feed consumed than the purebreds. Records were kept of the feed consumption until the chicks were five weeks of age. At this time, as previously mentioned, the chicks had to be removed from the battery brooders because of cannibalism. Sufficient space was not available to keep the chicks in separate groups afterwards and further records of feed consumption could not accordingly be had.

Tables XI, XII, XIII, XIV, and XV give the average number of chicks in each mating, the average weekly gain per chick, the average weekly feed consumption per chick, and the ratio of feed consumed to gain in weight. The data for the purebred Cornish and the Cornish-Red hybrids are not given. These two groups of chicks were kept in the same tray, and since both purebreds and hybrids were kept together, it was not possible to keep their feed records separate. The growth rate for these two groups of chicks was somewhat different, also. The data are not given for these reasons.

During the first week (Table XI), the purebred Leghorns showed the greatest gain, an average of 19.7 grams. At the same time they consumed the greatest amount of feed, 56.8

grams, and showed a ratio of one unit gain in weight to 2.88 units feed consumed. This ratio was the lowest of all the groups. The Minorca-Leghorn hybrids ranked second in gain in weight, averaging 17.4 grams. They also consumed the second highest amount of feed, 56.0 grams. The ratio of unit of gain to unit of feed consumed was second, being 3.22. The purebred Reds averaged 12.2 grams gain, the poorest for the week. They also consumed next to the least amount of feed, averaging 46.7 grams. The ratio 3.83 indicated that they consumed more feed per unit of gain than any of the other chicks.

During the second week (Table XII), the Giant-Leghorn hybrids made an average gain of 25.6 grams, the highest of all groups. These chicks consumed an average of 74.2 grams of feed, thus ranking fourth. The ratio of feed consumption to gain was 2.90, thus indicating that they made a greater gain per unit of feed than did the other groups. The Minorca-Leghorns ranked second in gain, with an average of 24.9 grams; first in feed consumption, with an average of 77.8 grams; second in amount of feed consumed per unit gain in weight, with a ratio of 3.12. The Reds gained the least, averaging 18.4 grams; consumed the least feed, the average being 68.3 grams, and were next to the poorest chicks in amount of gain per unit of feed consumed, the ratio being

3.71. The Cornish-Leghorns were the poorest in this last respect, with a ratio of 4.01.

The Minorca-Leghorns made the greatest gain the third week (Table XIII), averaging 46.9 grams. They also consumed the greatest amount of feed, averaging 115.2 grams. The ratio of gain to feed consumed was 2.46. The Leghorns were second in gain, averaging 44.6 grams, and were also second in feed consumed, averaging 112.8 grams. They were second in ratio of gain to feed consumed, with a ratio of 2.53. The Giant-Leghorns made the poorest gain, averaging 35.2 grams, and also consumed the least feed, averaging 96.8 grams. At the same time these chicks ranked last in the ratio of gain to feed consumption, the ratio being 2.75.

The Minorca-Leghorn hybrids were first during the fourth week (Table XIV), in average gain, this being 63.3 grams; they consumed the greatest amount of feed, averaging 169.3 grams; they were second in the ratio of gain to feed consumed, with a ratio of 2.67. The Cornish-Leghorns were second in average gain, this being 61.7 grams; they consumed the least feed, averaging 157.2 grams, and were first in ratio of gain to feed consumed with a ratio of 2.55. The Giant-Leghorns gained the least of all groups, averaging 56.0 grams; they ranked second to last in feed consumption, averaging 157.4 grams; they ranked third in ratio of gain to feed consumed, with a ratio of 2.81.

The purebred Reds made the greatest gain the fifth week (Table XV), averaging 100.5 grams; they consumed the greatest amount of feed, averaging 281.8 grams; they had the lowest ratio of feed consumed to gain, the ratio being 2.80. The Minorca-Leghorns were second in average gain, this being 87.7 grams; they were second in feed consumption, averaging 271.7 grams; and were next to last in ratio of gain to feed consumed, with a ratio of 3.10. The Cornish-Leghorns gained the least of all groups, averaging 74.6 grams; they consumed the least feed, averaging 234.5 grams; they were poorest in gain made per unit of feed consumed, having a ratio of 3.14.

Table XI. Feed consumption and gain for first week

Mating	Average number chicks	Average gain (grams) per chick	Average feed consumed (grams)	Ratio of feed consumed to gain
Giant X Leg.	74.4	13.8	45.3	3.28
Minorca X Leg.	73.2	17.4	56.0	3.22
White Leghorn	73.4	19.7	56.8	2.88
R. I. Red	73.6	12.2	46.7	3.83
Cornish X Leg.	53.3	13.0	47.1	3.62

Table XII. Feed consumption and gain for second week

Mating	Average number chicks	Average gain (grams) per chick	Average feed consumed (grams)	Ratio of feed consumed to gain
Giant X Leg.	74.0	25.6	74.2	2.90
Minorca X Leg.	73.0	24.9	77.8	3.12
White Leghorn	73.0	22.8	77.4	3.39
R. I. Red	68.0	18.4	68.3	3.71
Cornish X Leg.	52.0	19.2	77.0	4.01

Table XIII. Feed consumption and gain for third week

	Average number chicks	Average gain (grams) per chick	Average feed consumed (grams)	Ratio of feed consumed to gain
Giant X Leg.	73.4	35.2	96.8	2.75
Minorca X Leg.	72.0	46.9	115.2	2.46
White Leghorn	73.0	44.6	112.8	2.53
R. I. Red	65.1	37.4	100.1	2.68
Cornish X Leg.	51.0	38.0	98.8	2.60

Table XIV. Feed consumption and gain for fourth week

Mating	Average number chicks	Average gain (grams) per chick	Average feed consumed (grams)	Ratio of feed consumed to gain
Giant X Leg.	72.1	56.0	157.4	2.81
Minorca X Leg.	72.0	63.3	169.3	2.67
White Leghorn	73.0	58.4	166.7	2.85
R. I. Red	64.0	58.5	168.0	2.87
Cornish X Leg.	50.7	61.7	157.2	2.55

Table XV. Feed consumption and gain for fifth week

Mating	Average number chicks	Average gain (grams) per chick	Average feed consumed (grams)	Ratio of feed consumed to gain
Giant X Leg.	71.6	81.3	244.4	3.01
Minorca X Leg.	72.0	87.7	271.7	3.10
White Leghorn	72.3	85.4	253.0	2.96
R. I. Red	62.8	100.5	281.8	2.80
Cornish X Leg.	49.5	74.6	234.5	3.14

DISCUSSION

Somewhat conflicting results were obtained in the per cent mortality as found in the purebreds and the hybrids. The Cornish hybrids were much lower in per cent mortality than the purebred Cornish. This is the only instance in this phase of the experiment where the hybrids showed their superiority to the purebreds with regard to mortality. The Cornish-Reds showed a higher per cent mortality than the purebred Reds. The very poor vigor of the Cornish apparently influenced the vigor of these hybrids to a greater extent than that of the Reds, for the Reds were considerably lower in per cent mortality than the Cornish.

The Leghorn hybrids showed a slightly higher per cent mortality than the purebred Leghorns. The Giant-Leghorns showed the same per cent mortality as the purebred Leghorns, while the Minorca-Leghorns and Cornish-Leghorns were somewhat higher in per cent mortality than the purebred Leghorns. A satisfactory reason cannot be given for the higher per cent mortality in the hybrids than in the purebreds.

No reciprocal crosses were made in this part of the experiment, because the individuals necessary for the matings were not available. Only one group of chicks was produced from each of the groups of females used. For these reasons

comparisons as critical as those in the first phase cannot be made of the hybrids and purebreds in this phase. The best comparison of growth would probably be that between purebred and crossbred chicks from females of the same breed. The comparison would then be made between chicks from females laying approximately the same size eggs. This comparison is possible with the White Leghorn chicks and the three groups of Leghorn hybrids, and is also possible between the Red chicks and the one group of Red hybrids. With the Cornish and Cornish hybrids, this comparison is not possible.

In comparing the Leghorns and the Leghorn hybrids, it is to be seen from Table X and also figure 5 that the Leghorn hybrids were not heavier in every case than the purebreds, which was contrary to the results obtained in phase 1. The Minorca-Leghorns, the best hybrids of the entire second phase, grew faster than the purebred Leghorns, with the exception of the first week. The purebred Leghorns surpassed the Giant-Leghorns and the Cornish-Leghorns through the sixth week. At this age these two groups of hybrids averaged very nearly as much in weight as the Leghorns. At eight weeks, the Cornish-Leghorns were heavier than the purebred Leghorns, while the Giant-Leghorns were still slightly less in weight than the purebred Leghorns.

A comparison of the purebred Reds and the Cornish-Reds shows that the purebreds were consistently heavier than the hybrids, although at eight weeks the hybrids weighed almost as much as the purebreds.

The purebred Cornish, the Cornish-Leghorns, and Cornish -Reds are not as comparable as the other groups of chicks, as was previously explained. The Cornish hybrids were consistently heavier than the purebred Cornish with the exception of the first week's weight.

The study made on the relation between the amount of gain and the amount of feed consumed is not conclusive, for it extends over a period of just five weeks and only a few hundred chicks were involved. It does give an indication, however, that the amount of gain made is in direct relation to the amount of feed consumed. The chicks that consumed the most feed made the greatest gains, and those that consumed the least feed gained the least. Those chicks that consumed the most feed and made the greatest gains seemed to do it most economically. Where the greatest gains were made, there seemed to be a greater gain per unit of feed consumed. There were some exceptions to these statements, of course, but in most cases these conditions held true.

During some weeks the hybrids made more economical gains than did the purebreds, and during other weeks the

purebreds surpassed the hybrids. There were no indications that the hybrids were superior to the purebreds in economy in gain regarding the feed consumed.

There were results in phase 2, similar to those in phase 1, that indicated that the vigor of the purebreds was reflected in their hybrid offspring. If the vigor of the purebred chicks can be taken as representative of the vigor of the purebred parents, a direct comparison can be made between the purebreds and hybrids in this respect.

The purebred Leghorns were found to have the lowest per cent mortality of the purebreds. The Leghorn hybrids also showed the lowest per cent mortality of all hybrids. The Reds were intermediate in per cent mortality, and so were the Cornish-Red hybrids. The Cornish were highest of the purebreds in per cent mortality and the Cornish hybrids were accordingly the highest of the hybrids in per cent mortality.

The purebred Leghorns were the most rapid growing purebreds. The Leghorn hybrids were in turn the most rapid growing of all the hybrids. The purebred Cornish were the slowest growing purebreds and their hybrids were the slowest growing hybrids. The purebred Reds were not as rapid as the Leghorns in growth, which was contrary to the results in phase 1. The Red females used in the second phase were different individuals than those used in phase 1. This may

partially account for the difference. The Reds were more rapid growing, however, than the Cornish.

The Cornish-Reds were the slowest growing group of hybrids, coming from two slow growing purebreds. The Cornish-Leghorns were somewhat more rapid growing, showing that the rapid growing nature of the Leghorn had apparently offset the slow growing nature of the Cornish.

SUMMARY

1. The hybrids from the Barred Rock pullets and those from the Rhode Island Red females hatched earlier than the purebred chicks from these females.

2. The sex of chicks may be distinguished with a high degree of accuracy on the bases of the barring and non-barring factors and early- and late-feathering factors.

3. The per cent mortality in phase 1 of the purebred chicks was higher than in any group of hybrids. There were exceptions to this in phase 2.

4. The hybrids in phase 1 grew consistently faster than the purebreds. The hybrids in phase 2 did not grow faster than the purebreds in every case.

5. The chick weight at hatching was found to be associated with the weight at two weeks in all cases. This association was present in only fifty per cent of the cases at four weeks. At eight weeks, a slight degree of associa-

tion was found in one case.

6. The vigor of the purebreds seems to be reflected in their hybrid offspring.

7. The amount of gain in weight was found to be in direct relation with the amount of feed consumed in most cases. The chicks that consume the greatest amount of feed seem to make more economical gains. No indications were found that the hybrids were superior to the purebreds in economy in gain.

8. Hybrid vigor was obtained from some crosses, while it was not obtained from others.

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